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US 5621291 A **US 4845000 A** **US 4615071 A**

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(54) Abstract Title
Vacuum cleaner with wheels which may be driven at variable speeds

(57) A vacuum cleaner 10 being supported on or by a plurality of driven wheels or rollers 14 characterised in that the driven wheels or rollers 14 are adapted to be driven at more than one speed in a forward direction. The wheels or rollers 14 may also be adapted to drive at more than one speed in a backward direction. Preferable each wheel or roller 14 is connected to a separate motor (15 fig 5) and the speed of each wheel or roller 14 is regulated by control software connected to the wheel or roller 14, this software may use pulse width modulation. The vacuum cleaner 10 may be autonomous and may comprise navigation and control software for navigating about a room or other space. A cyclonic separator (52 fig 1) may be included.

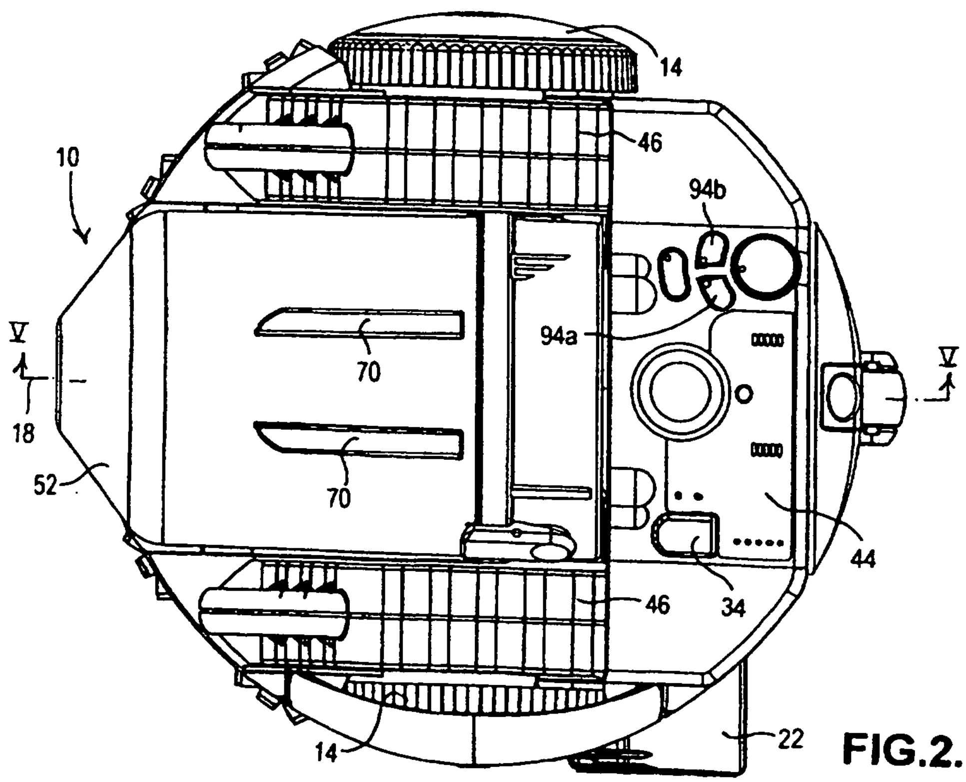


FIG.2.

GB 2 344 747

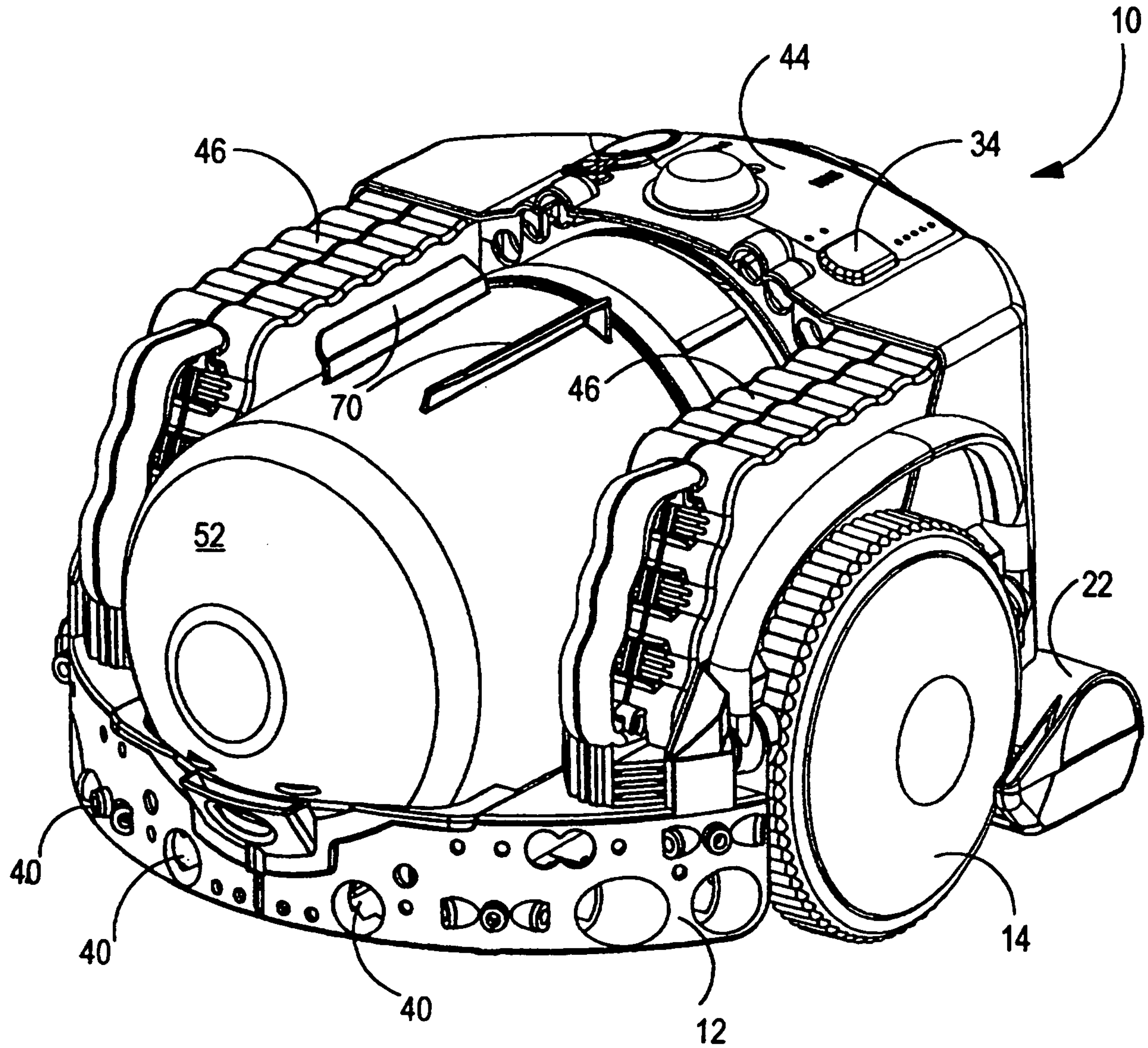


FIG.1.

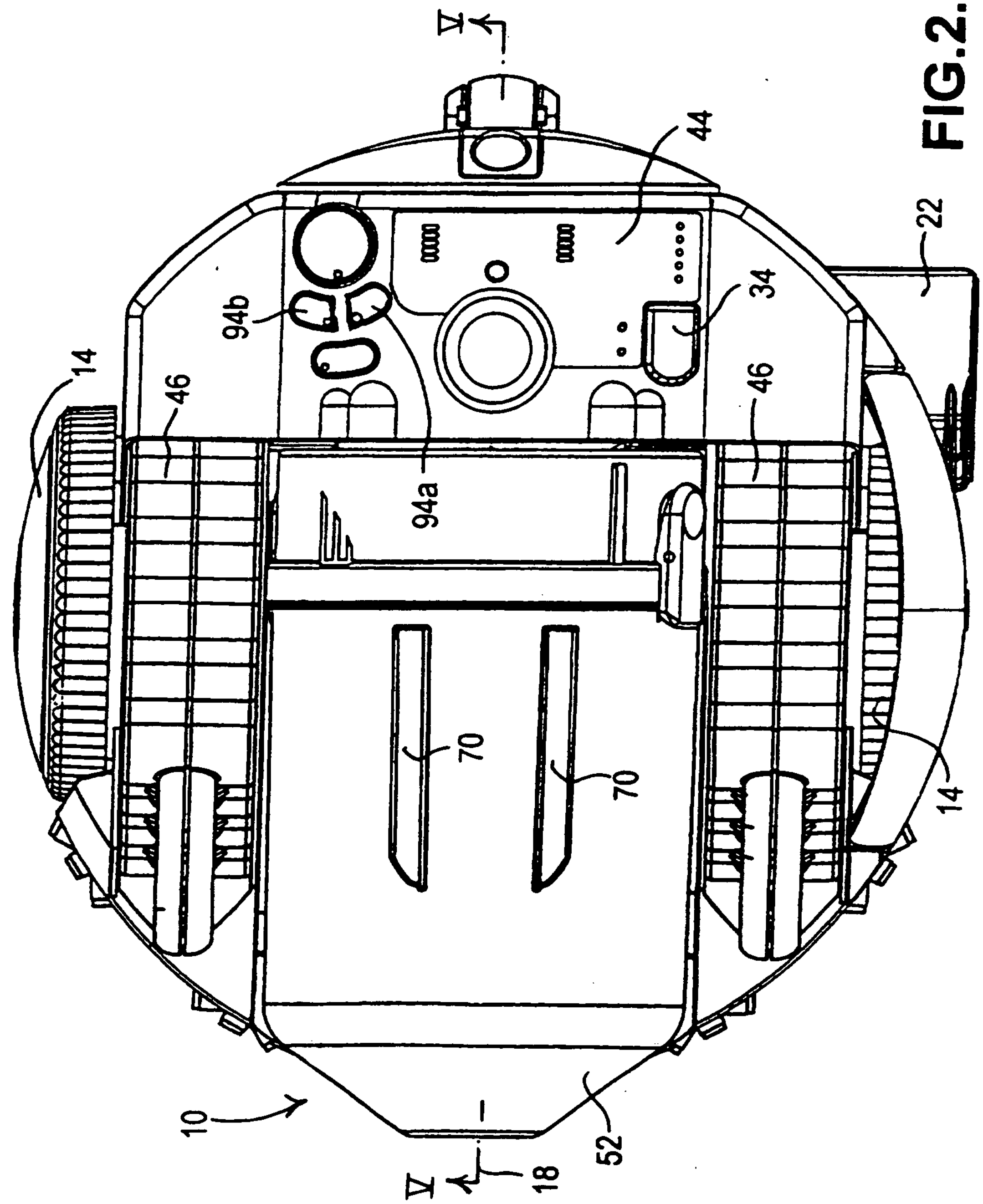


FIG.2.

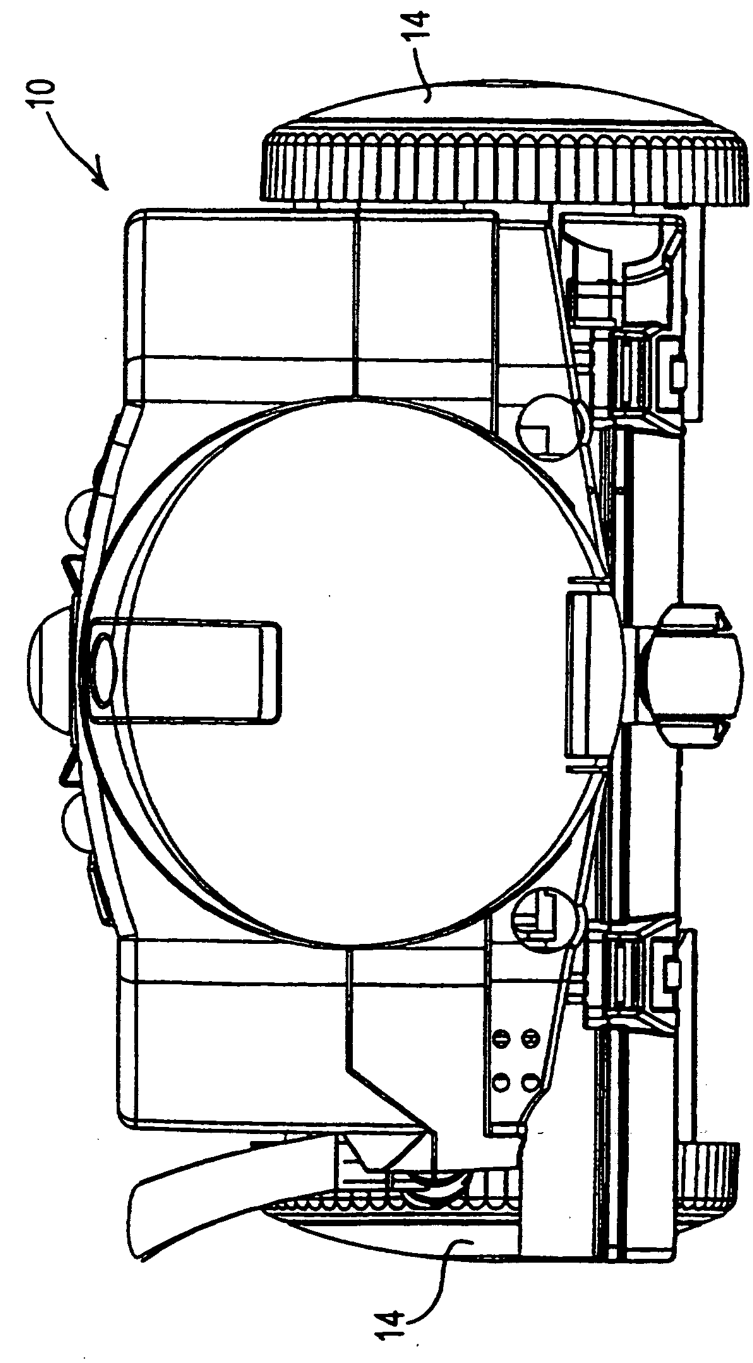


FIG.3.

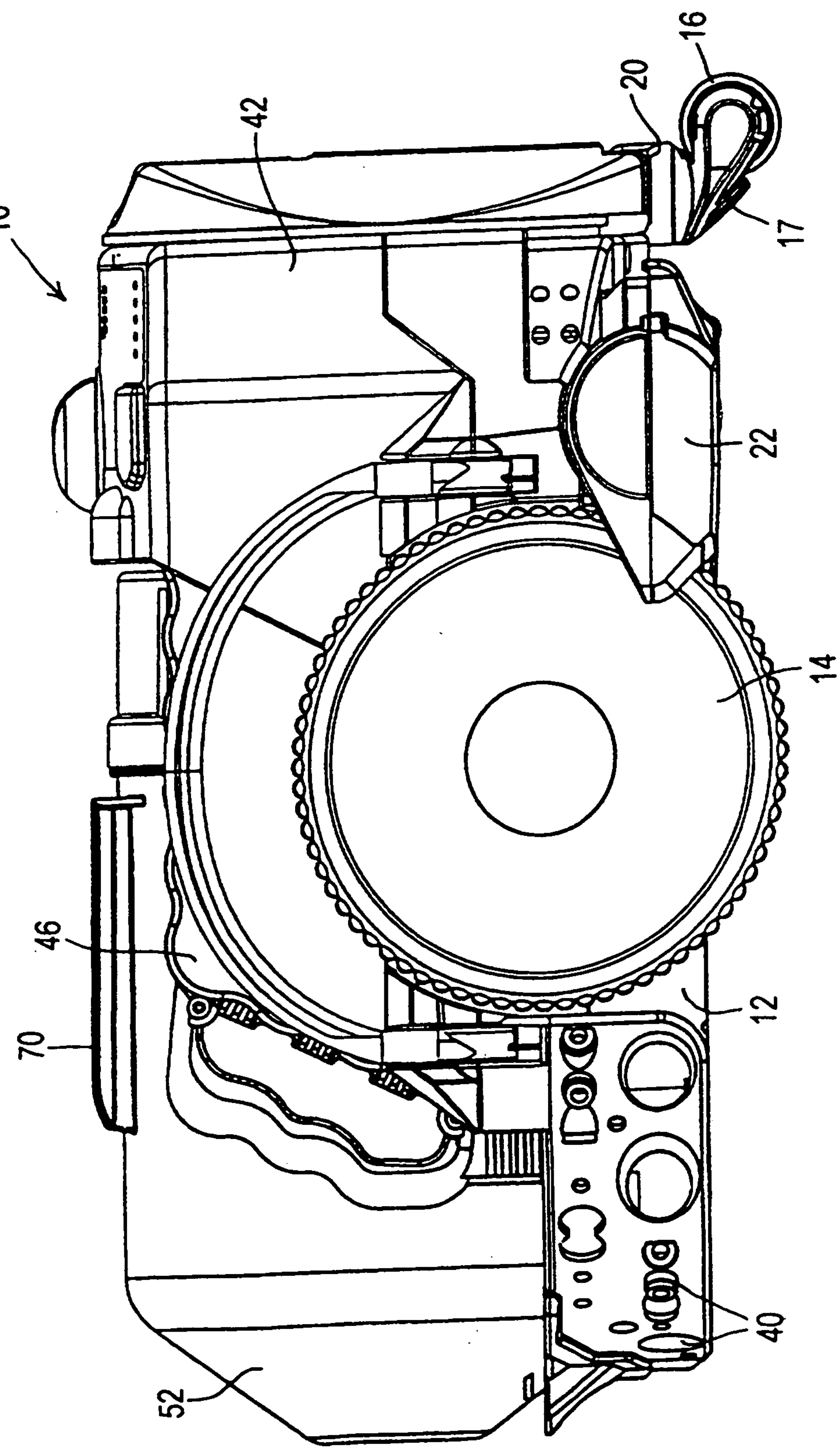


FIG.4.

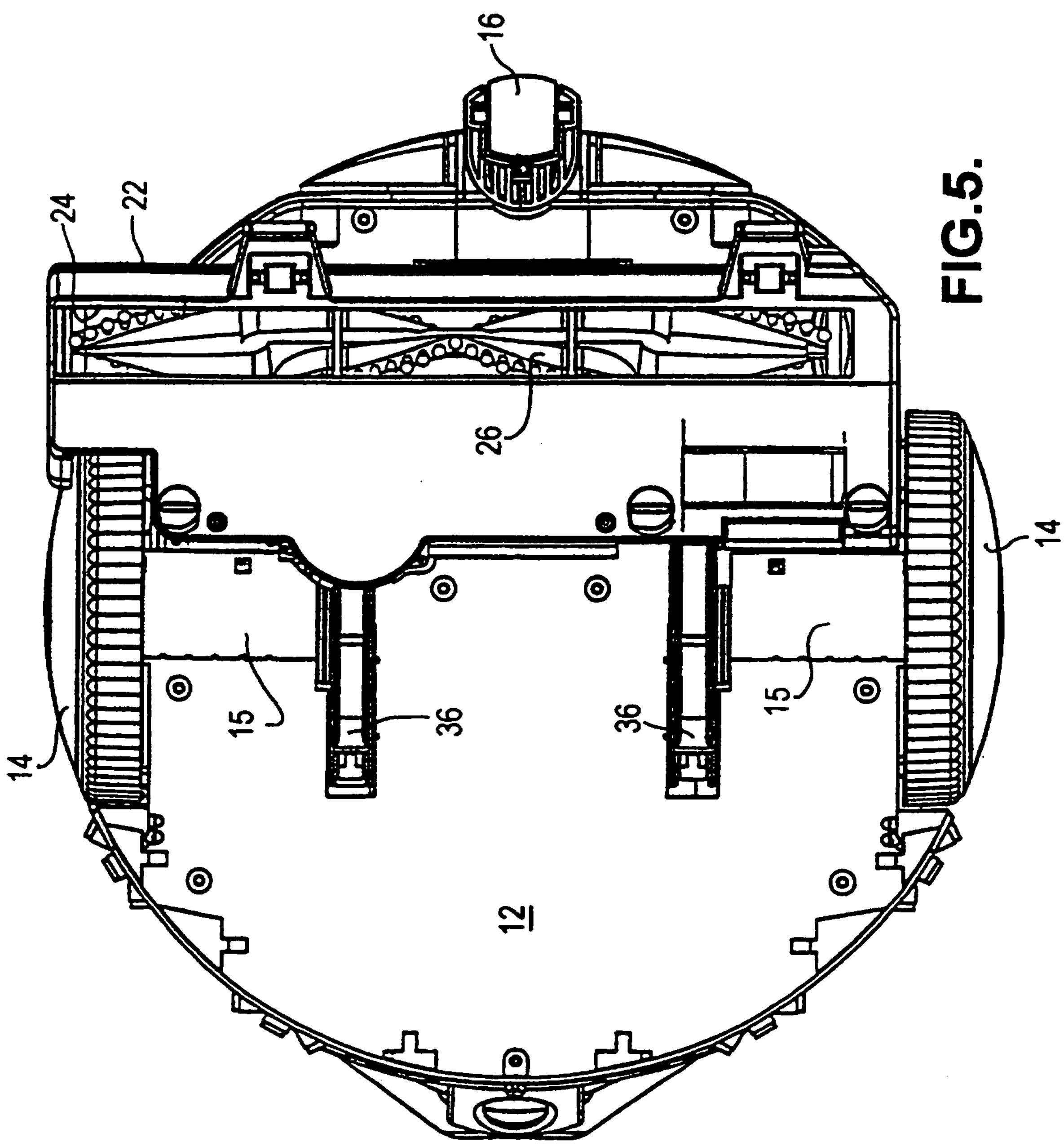


FIG.5.

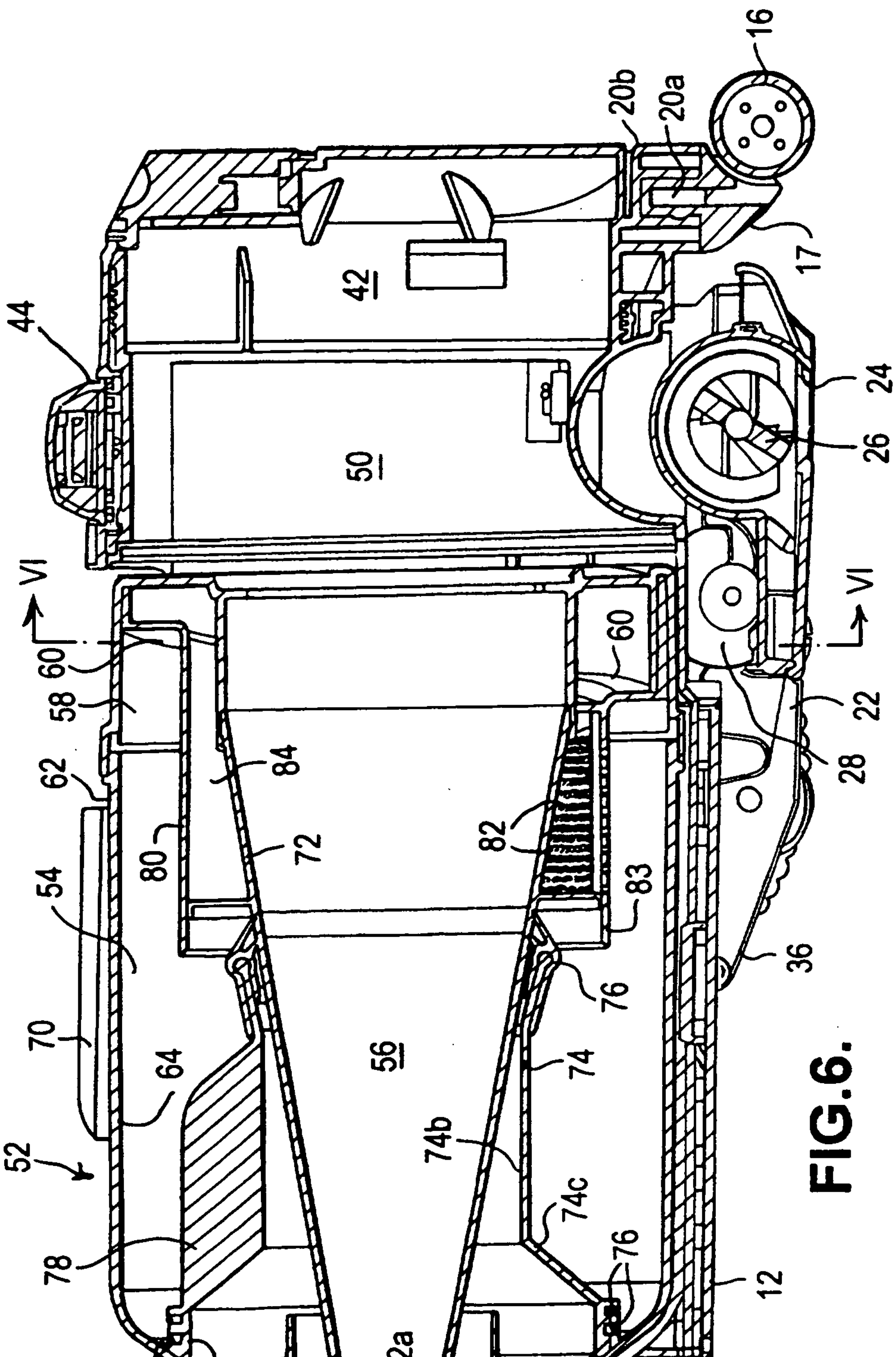
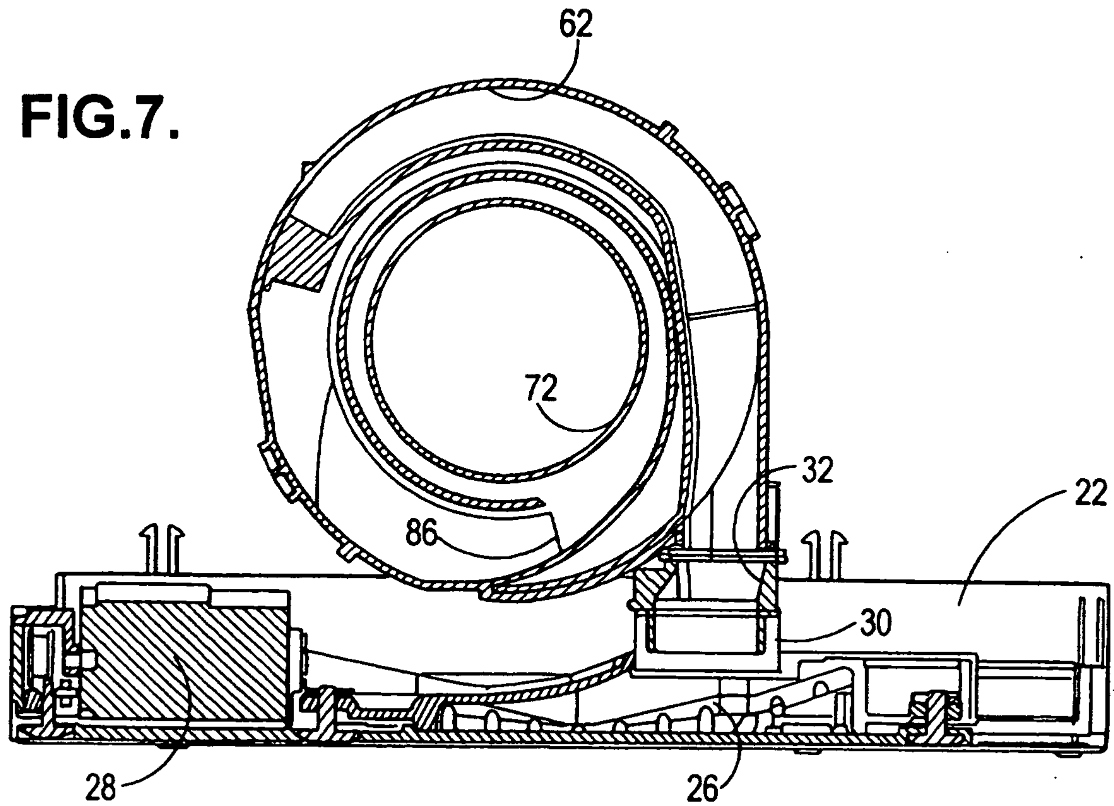

16
20b
20a
17
44
42
50
24
26
VI
VI
60
60
58
62
22
28
84
72
82
80
83
54
36
76
70
56
74
64
74b
52
74c
78
76
12
66
72a
74a
68

FIG.6.

FIG.7.



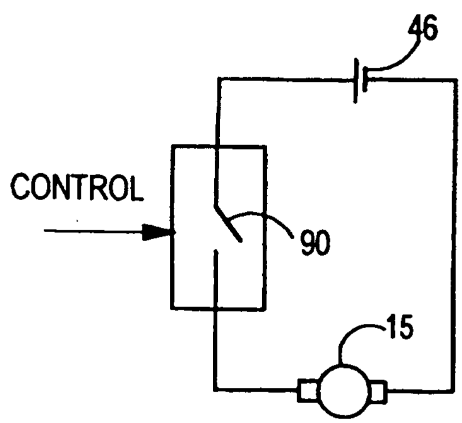


FIG.8a.

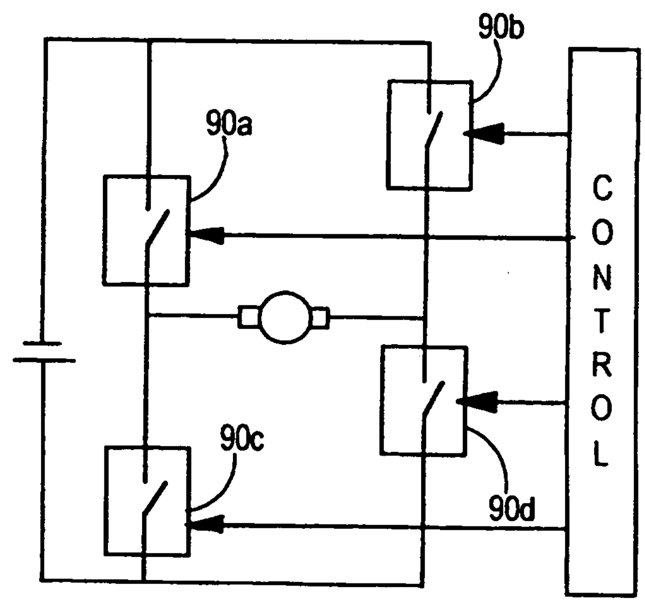


FIG.8b.

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Vacuum Cleaner

The invention relates to a vacuum cleaner, particularly to a driven vacuum cleaner.

By the term "driven vacuum cleaner" we mean a vacuum cleaner which comprises a main body or casing supported on wheels or rollers which are driven by an on-board drive mechanism. This means that the vacuum cleaner can be propelled over the surface to be cleaned without the user being required to push and pull the cleaner to any great extent. This can be of great benefit to elderly and/or disabled users of vacuum cleaners. Some upright cleaners incorporate such drive mechanisms so that the effort required from the user to move the cleaner is minimal. An example of such a self-propelled machine is shown and described in GB 2 106 200A. There have also been proposals for robotic or autonomous vacuum cleaners which are designed to operate without any human intervention at all. Examples are shown and described in US 5 781 960, US 5 682 640 and US 5 109 566.

A disadvantage of the self-propelled and autonomous vacuum cleaners is that they can only operate at a fixed speed in the normal, forward-moving direction. This is deliberate because the manner in which the cleaner picks up dirt and dust from the surface to be cleaned is determined by fixed factors, such as the speed of rotation and position of the brush bar, the power of the motor, etc. The speed of the cleaner is therefore fixed at a value which will give good pick up performance. This means that the cleaner can only clean a fixed surface area in a specified time and the possibility of cleaning a room in a short space of time is not available.

It is an object of the invention to provide a driven vacuum cleaner whose operation can be determined by the user to suit the user's requirements. It is a further object of the invention to provide a driven vacuum cleaner whose operation is more flexible than that of known vacuum cleaners.

The invention provides a vacuum cleaner having a main body containing or supporting dirt and dust separating apparatus, a motor and fan unit for drawing an airstream into the dirt and dust separating apparatus and a cleaner head for contacting a surface to be cleaned, the vacuum cleaner being supported on or by a plurality of driven wheels or rollers to allow the vacuum cleaner to traverse the surface to be cleaned, characterised in that the driven wheels or rollers are adapted to be driven at more than one speed in a forward direction. Such an arrangement allows the user to select a speed for the cleaner which will allow the respective surface to be covered at a comparatively fast or a comparatively slow speed. It may be perfectly acceptable, in some circumstances, to have the machine operate at a relatively high speed so that the surface is cleaned quickly, even though the pick-up performance may not be as good as when the cleaner is operating at a slower speed.

Preferably, the driven wheels or rollers are capable of being driven at a plurality of predetermined speeds in the forward direction. Alternatively, the driven rollers are capable of being driven at any speed within a predetermined range in the forward direction. Either of these arrangements will give the user more flexibility than has previously been available to users of this type of machine. It is still more preferable that the driven wheels or rollers can be driven at a plurality of speeds in a backward direction as well.

The invention has particular application in autonomous or robotic vacuum cleaners. It is also particularly advantageous if the vacuum cleaner is cyclonic in nature, although the invention can be applied to other forms of vacuum cleaner, such as those incorporating bag-type filters as their main form of dirt and dust separation apparatus, or those incorporating a combination of the two different types of separation apparatus.

Further and advantageous features are set out in the subsidiary claims.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a perspective view of a vacuum cleaner according to the invention;
Figure 2 is a plan view of the vacuum cleaner of Figure 1;
Figure 3 is a rear view of the vacuum cleaner of Figure 1;
Figure 4 is a side view of the vacuum cleaner of Figure 1;
Figure 5 is an underneath view of the vacuum cleaner of Figure 1;
Figure 6 is a sectional view taken along the line V-V of Figure 2;
Figure 7 is a sectional view taken along the line VI-VI of Figure 6 showing only the cleaner head and the cyclonic separator of the vacuum cleaner of Figure 1;
Figure 8a is a first circuit diagram of circuitry suitable for controlling a driven wheel of the vacuum cleaner of Figure 1; and
Figure 8b is a second circuit diagram of alternative circuitry suitable for controlling a driven wheel of the vacuum cleaner of Figure 1.

The vacuum cleaner 10 shown in the drawings is an autonomous machine. It has a supporting chassis 12 which is generally circular in shape and is supported on two driven wheels 14 and a castor wheel 16. The chassis 12 is preferably manufactured from high-strength moulded plastics material, such as ABS, but can equally be made from metal such as aluminium or steel. The chassis 12 provides support for the components of the cleaner 10 which will be described below. The driven wheels 14 are arranged at either end of a diameter of the chassis 12, the diameter lying perpendicular to the longitudinal axis 18 of the cleaner 10. Each driven wheel 14 is moulded from a high-strength plastics material and carries a comparatively soft, ridged band around its circumference to enhance the grip of the wheel 14 when the cleaner 10 is traversing a smooth floor. The driven wheels 14 are mounted independently of one another via support bearings (not shown) and each driven wheel 14 is connected directly to a motor 15 which is capable of driving the respective wheel 14 in either a forward direction or a reverse direction. Further details of the driving mechanism will be described below.

The castor wheel 16 is significantly smaller in diameter than the driven wheels 14 as can be seen from, for example, Figure 4. The castor wheel 16 is not driven and merely serves to support the chassis 12 at the rear of the cleaner 10. The location of the castor

wheel 16 at the trailing edge of the chassis 12, and the fact that the castor wheel 16 is swivellingly mounted on the chassis by means of a swivel joint 20, allows the castor wheel 16 to trail behind the cleaner 10 in a manner which does not hinder the manoeuvrability of the cleaner 10 whilst it is being driven by way of the driven wheels 14. The swivel joint 20 is most clearly shown in Figure 6. The castor wheel 16 is fixedly attached to an upwardly extending cylindrical member 20a which is received by an annular housing 20b to allow free rotational movement of the cylindrical member 20a therewithin. This type of arrangement is well known. The castor wheel 16 can be made from a moulded plastics material or can be formed from another synthetic material such as Nylon.

Mounted on the underside of the chassis 12 is a cleaner head 22 which includes a suction opening 24 facing the surface on which the cleaner 10 is supported. The suction opening 24 is essentially rectangular and extends across the majority of the width of the cleaner head 22. A brush bar 26 is rotatably mounted in the suction opening 24 and a motor 28 is mounted on the cleaner head 22 for driving the brush bar 26 by way of a drive belt (not shown) extending between a shaft of the motor 28 and the brush bar 26. The cleaner head 22 is mounted on the chassis 12 in such a way that the cleaner head 22 is able to float on the surface to be cleaned. This is achieved in this embodiment in that the cleaner head 22 is pivotally connected to an arm (not shown) which in turn is pivotally connected to the underside of the chassis 12. The double articulation of the connection between the cleaner head 22 and the chassis 12 allows the cleaner head to move freely in a vertical direction with respect to the chassis 12. This enables the cleaner head to climb over small obstacles such as books, magazines, rug edges, etc. Obstacles of up to approximately 25mm in height can be traversed in this way. A flexible connection 30 (see Figure 7) is located between a rear portion of the cleaner head 22 and an inlet port 32 (see also Figure 7) located in the chassis 12. The flexible connection 30 consists of a rolling seal, one end of which is sealingly attached to the upstream mouth of the inlet port 32 and the other end of which is sealingly attached to the cleaner head 22. When the cleaner head 22 moves upwardly with respect to the chassis 12, the rolling seal 30 distorts or crumples to accommodate the upward

movement of the cleaner head 22. When the cleaner head 22 moves downwardly with respect to the chassis 12, the rolling seal 30 unfolds or extends into an extended position to accommodate the downward movement.

In order to assist the cleaner head 22 to move vertically upwards when an obstacle is encountered, forwardly projecting ramps 36 are provided at the front edge of the cleaner head 22. In the event that an obstacle is encountered, the obstacle will initially abut against the ramps 36 and the inclination of the ramps will then lift the cleaner head 22 over the obstacle in question so as to avoid the cleaner 10 from becoming lodged against the obstacle. The cleaner head 22 is shown in a lowered position in Figure 6 and in a raised position in Figure 4. The castor wheel 16 also includes a ramped portion 17 which provides additional assistance when the cleaner 10 encounters an obstacle and is required to climb over it. In this way, the castor wheel 16 will not become lodged against the obstacle after the cleaner head 22 has climbed over it.

As can be seen from Figures 2 and 5, the cleaner head 22 is asymmetrically mounted on the chassis 12 so that one side of the cleaner head 22 protrudes beyond the general circumference of the chassis 12. This allows the cleaner 10 to clean up to the edge of a room on the side of the cleaner 10 on which the cleaner head 22 protrudes.

The chassis 12 carries a plurality of sensors 40 which are designed and arranged to detect obstacles in the path of the cleaner 10 and its proximity to, for example, a wall or other boundary such as a piece of furniture. The sensors 40 comprise several ultra-sonic sensors and several infra-red sensors. The array illustrated in Figures 1 and 4 is not intended to be limitative and the arrangement of the sensors does not form part of the present invention. Suffice it to say that the vacuum cleaner 10 carries sufficient sensors and detectors 40 to enable the cleaner 10 to guide itself or to be guided around a predefined area so that the said area can be cleaned. Control software, comprising navigation controls and steering devices, is housed within a housing 42 located beneath a control panel 44 or elsewhere within the cleaner 10. Battery packs 46 are mounted on the chassis 12 inwardly of the driven wheels 14 to provide power to the motors 15 for

driving the wheels 14 and to the control software. The battery packs 46 are removable to allow them to be transferred to a battery charger (not shown).

The vacuum cleaner 10 also includes a motor and fan unit 50 supported on the chassis 12 for drawing dirty air into the vacuum cleaner 10 via the suction opening 24 in the cleaner head 22. The chassis 12 also carries a cyclonic separator 52 for separating dirt and dust from the air drawn into the cleaner 10. The features of the cyclonic separator 52 are best seen from Figures 6 and 7. The cyclonic separator 52 comprises an outer cyclone 54 and an inner cyclone 56 arranged concentrically therewith, both cyclones 54, 56 having their coaxial axes lying horizontally. The outer cyclone 54 comprises an entry portion 58 which communicates directly with the inlet port 32 as shown in Figure 7. The inlet port 32 is arranged to be tangential to the entry portion 58 which is cylindrical and has an end wall 60 which is generally helical. The entry portion 58 opens directly into a cylindrical bin 62 having an outer wall 64 whose diameter is the same as that of the entry portion 58. The cylindrical bin 62 is made from a transparent plastics material to allow a user to view the interior of the outer cyclone 54. The end of the bin 62 remote from the entry portion 58 is frusto-conical in shape and closed. A locating ring 66 is formed integrally with the end of the bin at a distance from the outer wall 64 thereof and a dust ring 68 is also formed integrally with the end of the bin 62 inwardly of the locating ring 66. Located on the outer surface of the bin 62 are two opposed gripper portions 70 which are adapted to assist a user to remove the separator 52 from the chassis 12 for emptying purposes. Specifically, the gripper portions 70 are moulded integrally with the transparent bin 62 and extend upwardly and outwardly from the outer wall 64 so as to form an undercut profile as shown in Figure 1.

The inner cyclone 56 is formed by a partially-cylindrical, partially-frusto-conical cyclone body 72 which is rigidly attached to the end face of the entry portion 58. The cyclone body 72 lies along the longitudinal axis of the transparent bin 62 and extends almost to the end face thereof so that the distal end 72a of the cyclone body 72 is surrounded by the dust ring 68. The gap between the cone opening at the distal end 72a of the cyclone body 72 and the end face of the bin 62 is preferably less than 8mm.

A fine dust collector 74 is located in the bin 62 and is supported by the locating ring 66 at one end thereof. The fine dust collector 74 is supported at the other end thereof by the cyclone body 72. Seals 76 are provided between the fine dust collector 74 and the respective support at either end. The fine dust collector 74 has a first cylindrical portion 74a adapted to be received within the locating ring 66, and a second cylindrical portion 74b having a smaller diameter than the first cylindrical portion 74a. The cylindrical portions 74a, 74b are joined by a frusto-conical portion 74c which is integrally moulded therewith. A single fin or baffle 78 is also moulded integrally with the fine dust collector 74 and extends radially outwardly from the second cylindrical portion 74b and from the frusto-conical portion 74c. The outer edge of the fin 78 is aligned with the first cylindrical portion 74a and the edge of the fin 78 remote from the first cylindrical portion 74a is essentially parallel to the frusto-conical portion 74c. The fin 78 extends vertically upwardly from the fine dust collector 72.

A shroud 80 is located between the first and second cyclones 54, 56. The shroud 80 is cylindrical in shape and is supported at one end by the entry portion 58 and by the cyclone body 72 of the inner cyclone 56 at the other end. As is known, the shroud 80 has perforations 82 extending therethrough and a lip 83 projecting from the end of the shroud 80 remote from the entry portion 58. A channel 84 is formed between the shroud 80 and the outer surface of the cyclone body 72, which channel 84 communicates with an entry port 86 leading to the interior of the inner cyclone 56 in a manner which forces the incoming airflow to adopt a swirling, helical path. This is achieved by means of a tangential or scroll entry into the inner cyclone 56 as can be seen from Figure 7. A vortex finder (not shown) is located centrally of the larger end of the inner cyclone 56 to conduct air out of the cyclonic separator 52 after separation has taken place. The exiting air is conducted past the motor and fan unit 50 so that the motor can be cooled before the air is expelled to atmosphere. Additionally, a post-motor filter (not shown) can be provided downstream of the motor and fan unit 50 in order to further minimise the risk of emissions into the atmosphere from the vacuum cleaner 10.

The entire cyclonic separator 52 is releasable from the chassis 12 in order to allow emptying of the outer and inner cyclones 54, 56. A hooked catch (not shown) is provided adjacent the inlet port 32 by means of which the cyclonic separator 52 is held in position when the cleaner 10 is in use. When the hooked catch is released (by manual pressing of a button 34 located in the control panel 44), the cyclonic separator 52 can be lifted away from the chassis 12 by means of the gripper portions 70. The bin 62 can then be released from the entry portion 58 (which carries with it the shroud 80 and the inner cyclone body 72) to facilitate the emptying thereof.

The operation of the driven wheels 14 will now be described in more detail. In most prior art arrangements, the motors which drive the driven wheels are arranged simply to drive the said wheels either forwards or backwards (ie. bi-directional motors are used) at a fixed speed. Driving both wheels forwards will result in the cleaner being driven forwards in a straight line. Similarly, driving both wheels backwards will cause the cleaner to travel backwards in a straight line. Driving the wheels in opposite directions at the same speed will turn the cleaner about its own axis, and driving the wheels in the same direction but at different speeds will cause the cleaner to turn a corner. The cleaner 10 described above is capable of all of the above movements but is also arranged to allow the user either to select one speed from a range of predetermined speeds, or else to select a speed falling within a predetermined range of speeds.

The motors 15 used in the illustrated embodiment are 36V DC gear motors with an 18:1 reduction ratio. The maximum power output during normal operation is approximately 8W and the torque produced is approximately 430mNm. Each motor 15 is mounted on the underside of the chassis 12 and the output shaft of each motor 15 is connected directly to the respective driven wheel 14. During normal operation, ie operation in which the speed of the cleaner 10 is such that the pickup performance of the cleaner head 22 is good, the output of the motors 15 is such that the cleaner 10 is driven across the surface to be cleaned at a speed of approximately 0.25m/s. Each motor 15 is

connected to the control software mentioned above, which has a pulse width modulation capability. Using pulse width modulation methods, the control software is able to alter the speed at which each motor 15 drives the respective driven wheel 14. The control software is thus able to select the speed at which the cleaner 10 travels across the surface to be cleaned. By increasing the speed at which the cleaner 10 travels across the surface to be cleaned (to, for example, approximately 0.45m/s), a fixed amount of floor space can be covered in a shorter time. Alternatively, a larger area of floor space can be covered in a fixed time (eg the discharge time of the batteries 46). It will be appreciated that, in some cases, the performance of the vacuum cleaner will not be quite as good as it would have been if the cleaner 10 had been traveling at the optimum speed, but this will be acceptable in some cases. A rapid, almost cursory cleaning can then be carried out. Similarly, by decreasing the speed at which the cleaner 10 travels across the floor, a very thorough cleaning can be achieved. This might be necessary in circumstances when the surface to be cleaned is particularly heavily soiled.

Figure 8a is a simple circuit diagram showing how one of the motors 15 can be connected to achieve the desired effect. The motor 15 is connected to the battery 46 via a switch 90. The switch 90 is controlled by means of the control software referred to above so as to effect pulse width modulation. By closing the switch 90 for pulses which are of the same width as pulses for which the switch 90 is open, the average amount of current supplied to the motor 15 is half that which could have been supplied by the battery 46 without pulse width modulation. If the battery produces a voltage of 36V, the motor 15 would then behave substantially as if a voltage of 18V had been supplied and would turn at approximately half the rotational speed accordingly. Increasing the length of the pulses during which the switch 90 is closed, in comparison to the length of the pulses during which the switch 90 is open, results in an increase in the proportion of the maximum current which is supplied to the motor 15 and a resultant increase in the speed of the motor is achieved in the normal manner of pulse width modulation. The speed of the motor 15 can therefore be controlled in order to produce a desired forward speed of the cleaner 10.

The circuit shown in Figure 8a is capable of driving the motor 15 only in one direction. As an alternative, the circuit shown in Figure 8b is capable of driving the motor 15 (which is bi-directional) in either direction. Essentially, the circuit consists of a standard H-bridge in which the switches 90a, 90b, 90c and 90d are connected to the control software so that the desired voltage is applied to the motor 15 in the correct direction in order to drive the motor 15 in the desired direction. It is envisaged that, for the application currently under consideration, the H-bridge circuit shown in Figure 8b will be a standard MOSFET driver integrated circuit.

It will be appreciated that the circuitry by means of which the motor 15 is connected to the control software and to the batteries 46 will preferably be identical in each case. The use of pulse width modulation to achieve the desired regulation of the speed of the motors 15, and therefore of the wheels, allows the user to select a suitable speed of travel of the cleaner 10 for the job to be done. In the embodiment illustrated, the cleaner 10 includes buttons 94a, 94b located in the control panel 44 (see Figure 2) by means of which the user can select either a high speed or a low speed of movement of the cleaner 10 across the surface to be cleaned. By pressing button 94a, the user selects a low speed and by pressing button 94b, the user selects a high speed. When the low speed is selected, the cleaner operates at a speed at which the pick up performance of the brush bar effects a high standard of cleaning and, when the high speed is selected, the cleaner operates at a higher speed in order to travel more quickly over the surface to be cleaned. Whilst the quicker cleaning operation may not effect as thorough a clean as the slower cleaning operation, there are times when the time available will not be sufficient to allow the slower operation to take place and the quicker option is then very useful and effective. Alternatively, the user may wish to ensure that a larger area is covered than would be coverable when the lower speed is selected.

It will be appreciated that the control software can be used to turn the cleaner 10, either about its own axis or around a corner, in the usual manner of slowing or reversing one of the wheels 14 compared to the other wheel 14. When a fast speed is selected for the operation of the cleaner 10, the control software merely selects appropriate ratios of the

faster speed for each wheel in order to effect the turn. Thus the cleaner 10 is able to turn at a fast speed as well as travel in a forward direction at that fast speed. The same is true for slower speeds and for reverse movement.

The control software is also capable of using pulse width modulation to ramp up and ramp down the speed of the cleaner 10 when it is starting and stopping. This is more energy efficient and also gives a smoother motion to the cleaner 10. Ramping up and ramping down of starting and stopping speeds is well known and need not be described any further here.

As an alternative to the two buttons 94a, 94b illustrated in Figure 2 of the drawings, it is equally possible to provide an arrangement in which the user may select any speed of the cleaner 10 within a predetermined range of speeds. A knob or slide selector can then be provided which will allow the user to select the desired speed. Effectively, the knob or slide selector will provide a signal to the control software which will then drive the motors 15 at a specific speed in comparison to the speed designed to achieve the better pick up performance. Push buttons effecting incremental increases and decreases in the selected speed are equally appropriate. It would also be desirable to provide a display showing the speed (or relative speed) selected at any particular time. Such a display could be permanent or optional.

The vacuum cleaner 10 described above operates generally in the following manner. In order for the cleaner 10 to traverse the area to be cleaned, the wheels 14 are driven by the motors 15 which, in turn, are powered by the batteries 46 and controlled by the control software. The speed of travel of the cleaner 10 over the surface to be cleaned is selected by the user to suit requirements using either the buttons 94a, 94b or alternative selector means. The direction of movement of the cleaner 10 is determined by the control software which communicates with the sensors 40 which are designed to detect any obstacles in the path of the cleaner 10 so as to navigate the cleaner 10 around the area to be cleaned. Methodologies and control systems for navigating a robotic vacuum cleaner around a room or other area are well documented elsewhere and do not form

part of the inventive concept of this invention. Any of the known methodologies or systems could be implemented here to provide a suitable navigation system.

The batteries 46 also provide power to operate the motor and fan unit 50 to draw air into the cleaner 10 via the suction opening 24 in the cleaner head 22. The motor 28 is also driven by the batteries 46 so that the brush bar 26 is rotated in order to achieve good pick-up, particularly when the cleaner 10 is to be used to clean a carpet. The dirty air is drawn into the cleaner head 22 and conducted to the cyclonic separator 52 via the telescopic conduit 30 and the inlet port 32. The dirty air then enters the entry portion 58 in a tangential manner and adopts a helical path by virtue of the shape of the helical wall 60. The air then spirals down the interior of the outer wall 64 of the bin 62 during which motion any relatively large dirt and fluff particles are separated from the airflow. The separated dirt and fluff particles collect in the end of the bin 62 remote from the entry portion 58. The fin 78 discourages uneven accumulation of dirt and fluff particles and helps to distribute the dirt and fluff collected around the end of the bin 62 in a relatively even manner.

The airflow from which dirt and larger fluff particles has been separated moves inwardly away from the outer wall 64 of the bin 62 and travels back along the exterior wall of the fine dust collector 74 towards the shroud 80. The presence of the shroud 80 also helps to prevent larger particles and fluff traveling from the outer cyclone 54 into the inner cyclone 56, as is known. The air from which comparatively large particles and dirt has been separated then passes through the shroud 80 and travels along the channel between the shroud 80 and the outer surface of the inner cyclone body 72 until it reaches the inlet port 86 to the inner cyclone 56. The air then enters the inner cyclone 56 in a helical manner and follows a spiral path around the inner surface of the cyclone body 72. Because of the frusto-conical shape of the cyclone body 72, the speed of the airflow increases to very high values at which the fine dirt and dust still entrained within the airflow is separated therefrom. The fine dirt and dust separated in the inner cyclone 56 is collected in the fine dust collector 74 outwardly of the dust ring 68. The dust ring 68 discourages re-entrainment of the separated dirt and dust back into the airflow.

When the fine dirt and dust has been separated from the airflow, the cleaned air exits the cyclonic separator via the vortex finder (not shown). The air is passed over or around the motor and fan unit 50 in order to cool the motor before it is expelled into the atmosphere.

The provision of a facility for selecting the speed of the cleaner 10 (preferably in comparison to the speed at which the better pick up performance is achieved) gives the user much greater flexibility when using the cleaner. The nature of the robotic vacuum cleaner means that it may take between 15 and 30 minutes to cover all of the floor area which is required to be cleaned. There are instances in which those 15 to 30 minutes may not be available to the user and it is desirable that the floor area in question be cleaned in a shorter space of time, but that a lower level of cleaning can be tolerated. In these cases, the cleaner can be set to cover a room in half the normal time, or less. Alternatively, a greater area of floor space may need to be covered in a fixed space of time and a higher speed can then be advantageously selected.

It will be appreciated that there are features which have been described above in conjunction with the cleaner 10 which are immaterial to the invention to which this application relates. For example, the manner in which the cleaner navigates about a floor area to be cleaned is not directly connected to the invention and this can be effected in any suitable manner, as can the manner in which the dirt and dust is separated from the airflow which enters the cleaner 10. The separation can be effected by means of a cyclonic separator as illustrated, by a standard bag-type filter, by a plain filter or by any combination of these. Furthermore, the manner in which the cleaner head is connected to the chassis can be replaced by any other suitable connection or configuration of the cleaner head. The invention is specifically intended to be directed to the manner in which the supporting wheels are driven by the motors so as to allow the user to control the speed at which the cleaner operates.

Claims:

1. A vacuum cleaner having a main body containing or supporting dirt and dust separating apparatus, a motor and fan unit for drawing an airstream into the dirt and dust separating apparatus and a cleaner head for contacting a surface to be cleaned, the vacuum cleaner being supported on or by a plurality of driven wheels or rollers to allow the vacuum cleaner to traverse the surface to be cleaned, characterised in that the driven wheels or rollers are adapted to be driven at more than one speed in a forward direction.

2. A vacuum cleaner as claimed in claim 1, wherein the driven wheels or rollers are capable of being driven at a plurality of predetermined speeds in the forward direction.

3. A vacuum cleaner as claimed in claim 1, wherein the driven rollers are capable of being driven at any speed within a predetermined range in the forward direction.

4. A vacuum cleaner as claimed in any one of the preceding claims, wherein the wheels or rollers are each connected to a motor adapted to drive the respective wheel or roller.

5. A vacuum cleaner as claimed in claim 4, wherein each wheel or roller is connected to a separate motor.

6. A vacuum cleaner as claimed in claim 4 or 5, wherein control software is connected to the or each motor in order to regulate the speed of the or each wheel or roller.

7. A vacuum cleaner as claimed in claim 6, wherein the control software makes use of pulse width modulation in order to regulate the speed of the or each motor.

8. A vacuum cleaner as claimed in any one of the preceding claims, wherein the driven wheels or rollers are adapted to be driven at more than one speed in a backward direction.

9. A vacuum cleaner as claimed in claim 8, wherein the driven wheels or rollers are capable of being driven at a plurality of predetermined speeds in the backward direction.

10. A vacuum cleaner as claimed in claim 8, wherein the driven rollers are capable of being driven at any speed within a predetermined range in the backward direction.

11. A vacuum cleaner as claimed in any one of the preceding claims, wherein at least one non-driven wheel or roller is provided in addition to the driven wheels or rollers.

12. A vacuum cleaner as claimed in any one of the preceding claims, wherein the vacuum cleaner has a control for selecting one of a number of predetermined speeds at which the cleaner will traverse the surface to be cleaned.

13. A vacuum cleaner as claimed in claim 12, wherein one of the predetermined speeds is a slow speed.

14. A vacuum cleaner as claimed in claim 12 or 13, wherein one of the predetermined speeds is a fast speed.

15. A vacuum cleaner as claimed in any one of the preceding claims, wherein the dirt and dust separating apparatus comprises a cyclonic separator.

16. A vacuum cleaner as claimed in claim 15, wherein the cyclonic separator comprises two cyclones arranged in series.

17. A vacuum cleaner as claimed in any one of the preceding claims, wherein the vacuum cleaner is autonomous.

18. A vacuum cleaner as claimed in claim 17, wherein the main body comprises navigation and control software for navigating the vacuum cleaner about a room or other enclosed space.

19. A vacuum cleaner substantially as hereinbefore described with reference to the accompanying drawings.

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Claims searched: 1-19

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): A4F (FSCT FSDM FSDT FSDX FCCX)

Int Cl (Ed.6): A47L (5/00 9/00 9/28 11/40)

Other: Online: wpi

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	US 5621291	(SAMSUNG) see especially column 2 lines 9-14 and column 2 lines 65 to column 3 line 61	1-6, 8-14, 17, 18
X	US 4854000	(TAKIMOTO) see column 2 lines 28-39	1-4, 8-10, 12-14
X	US 4615071	(WHIRLPOOL CORPORATION) see column 1 lines 41-46, column 2 line 55 to column 3 line 19 and column 5 lines 32-34	1-4, 8-10, 12-14

X Document indicating lack of novelty or inventive step
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